POWER FLOW EFFICIENCY OF A DC DISTRIBUTION GRID

A test case with a High Penetration of Renewable Energy Resources in Different Operational Modes

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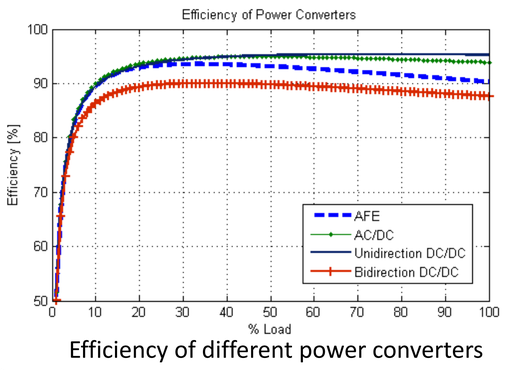
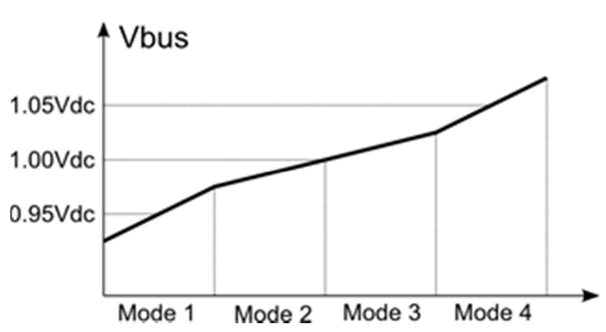
Introduction and Objectives

- A DC local distribution grid is a suitable solution for PV arrays, PHEVs and energy storage systems without AC-DC conversion.
- A model of an 400V DC local residential distribution grid with penetration of distributed energy resources (DER), which are expected to increase significantly in the future, is studied.
- Evaluate the efficiency of DC grid in terms of steady-state power flow and total losses.

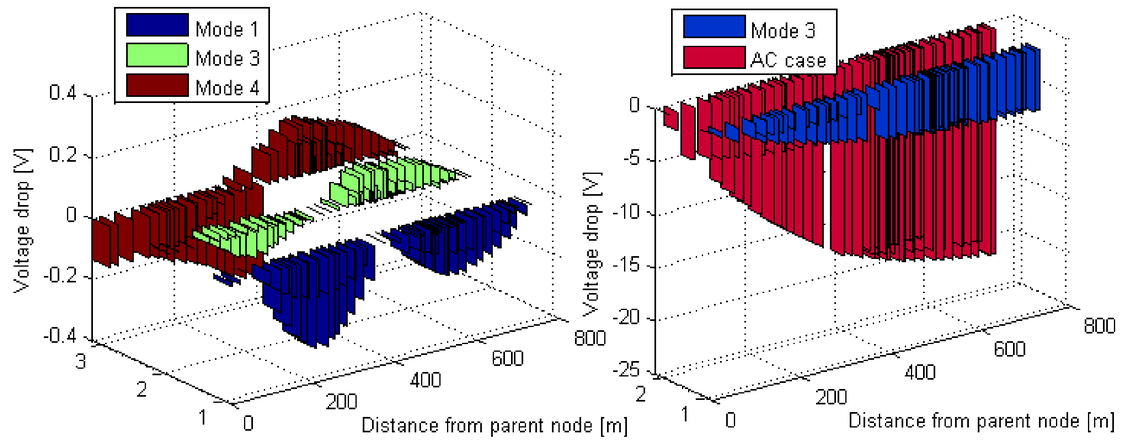
Assumption



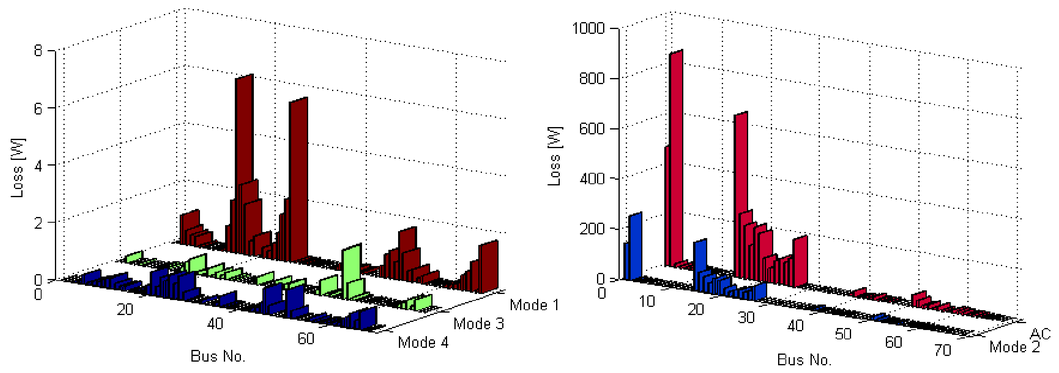
Efficiency of different power converters



Operational modes of the proposed DC grid



Differences of voltage drop compared to base voltage



Branch losses at different cases

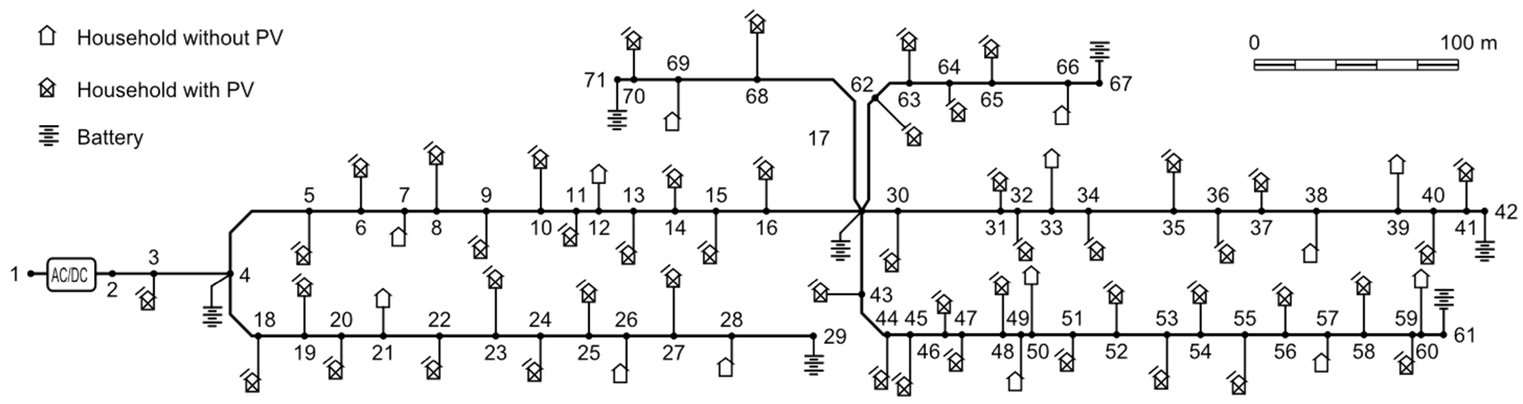
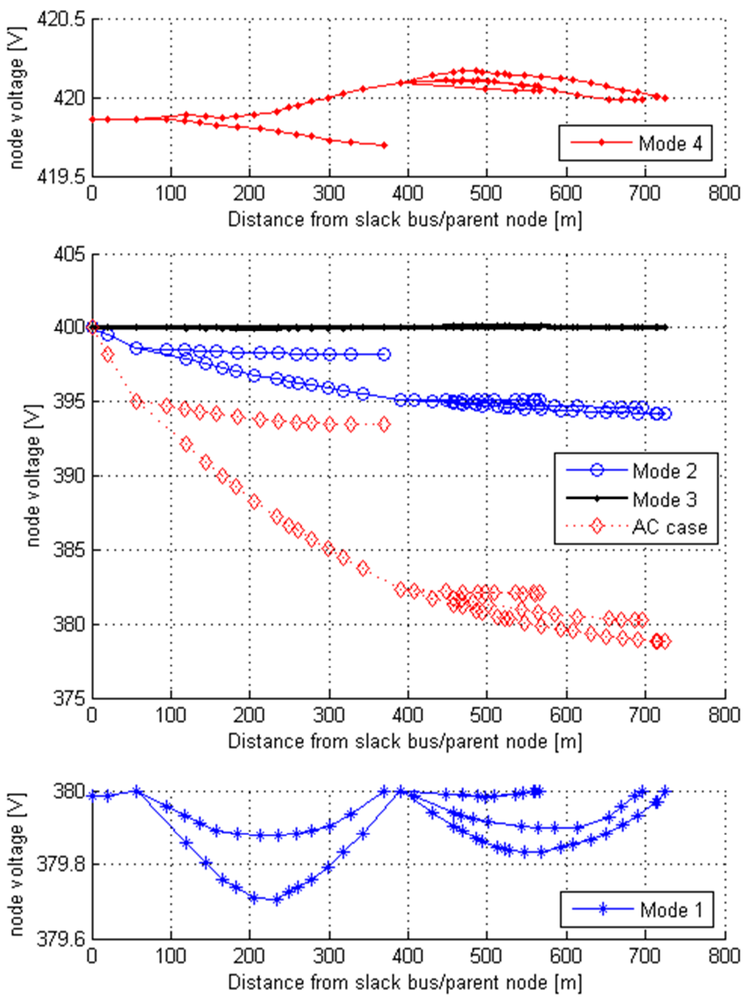


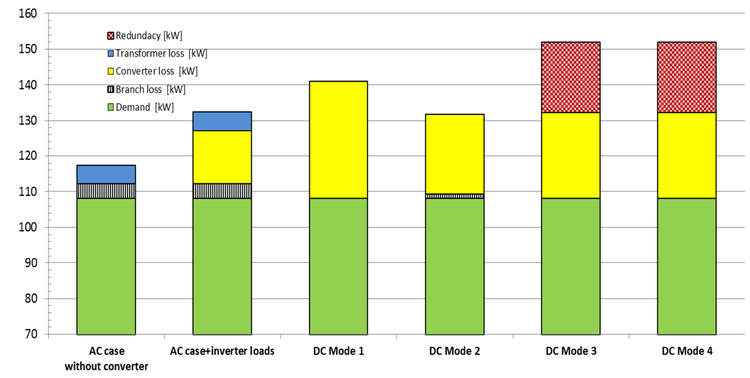
Diagram of the DC semi-urban network



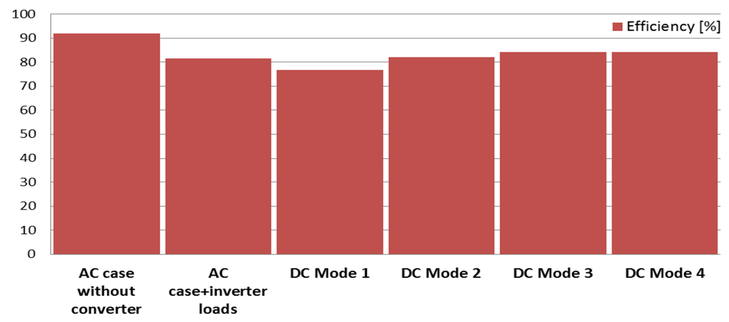
Voltage drop in AC architecture and DC architecture

Power demand	**108.08 kW**
Length of the main feeder	725 m
Cable type	EXVB 1kV_ 4x150 (main feeder) EXVB 1kV_ 4x95 (main feeder) EXVB 1kV_ 4x16 (to loads/PVs)
Transformer	ABB EcoDry Basic 250kVA, 24/0.4KV
Power electronic switch	IGBTs 1200V, forced air cooling AFE: 400V/250 KVA DC/DC converter: 400V/10KVA DC/AC converter: 400V/10KVA DC/DC bi-directional: 400V/100kVA
Energy storage	Pb-acid battery, 34 packs 12V

Results



Contribution of demand and losses
in total required power of different test cases



Efficiency of power in different test modes

Conclusions and Perspectives

- Efficiency highly depends on the working load relative to the rated capacity of converters and the modes of operations of DC networks.
- Efficiency gain of DC power distribution architecture is limited compared to AC case.
- DC efficiency on data centers in published papers achieve 5-20% efficiency gain while the efficiency gain of a DC local distribution grid in this paper is limited from 0.4 to 2.5%.
- However, DC power distribution holds the most advantage for the connection of emerging technologies for on-site power generation and energy storage as a significant amount of this equipment delivers power in the form of DC or alternatively as high frequency AC, which then requires an intermittent DC conversion.
- The efficient issues of primary reserves and power flow redistribution via power electronic conversions in transient are being investigated.

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